Prof. T. E. Avery
Northern Arizona Univ.
Flagstaff, Arizona 86001
James Canning
New Zealand Forest Service
Rotorua, New Zealand

Airphoto Measurements Of New Zealand Pines

Contrary to previous beliefs, the Zeiss RMK-A-60/23 aerial camera with a 30° lens and a 24-inch focal length is suitable for parallax measurements.

Abstract: *Panchromatic and color aerial photographs at a scale of 1:3,000 were obtained for thinned strands of* Pinus radiata *near Rotorua, New Zealand. With color transparencies, neophyte interpreters were able to make acceptable stem counts, measure tree heights within ± 5 feet, and crown diameters within ± 2 feet.*

Introduction

Although exotic coniferous plantations comprise a relatively small proportion of New Zealand's total forest area, such plantings command a sizeable share of management and research expenditures. Much of the management effort is directed at coniferous species from North America, with particular emphasis on *Pinus radiata,* commonly termed *radiata pine* (Figure 1).

The need for periodic inventories of radiata pine plantations has led to investigations of airphoto techniques that might be applicable for obtaining stand measurements needed after thinning operations. Thus in 1970-71, a study was undertaken at Kaingaroa State Forest* near Rotorua, New Zealand to determine how precisely tree crown diameters, tree heights, and stem counts could be determined in thinned stands of radiata pine.

Twenty 0.1-acre, circular sample plots were located in stands with densities of 90 to 250 stems per acre. The plantation was approximately 12 to 13 years old on the date of photography, and the most recent thinnings had been made 6 to 12 months prior to photographic flights. Trees were approximately 5 to 12 inches in diameter and 40 to 70 feet in height. Tree locations were mapped for subsequent comparisons with photographic measurements. Then, for each of the 304 trees tallied, field measurements of stem diameter, crown diameter, and tree height were recorded.

*Approximate location is 38.5° South latitude, 176.5° East longitude. Average ground elevation is 1,800 feet above MSL.

Aerial Photography

Overlapping aerial photographs with a considerable degree of stereoscopic parallax are needed for measuring the heights of objects; conversely, a minimum of parallax (or relative image displacement) is desired for determining crown diameters and stems per acre. Therefore, the necessity of measuring *all three* stand parameters must inevitably result in some degree of compromise in developing specifications for forest inventory photography. The objective is to obtain high-resolution photographs with a sufficient degree of relative image displacement to permit reliable measurements of object heights, but not enough displacement to interfere with linear measurements and object counts. Where large-scale photography of forest areas is planned, this objective is usually achieved with aerial cameras having lens angles of 60 degrees or less.

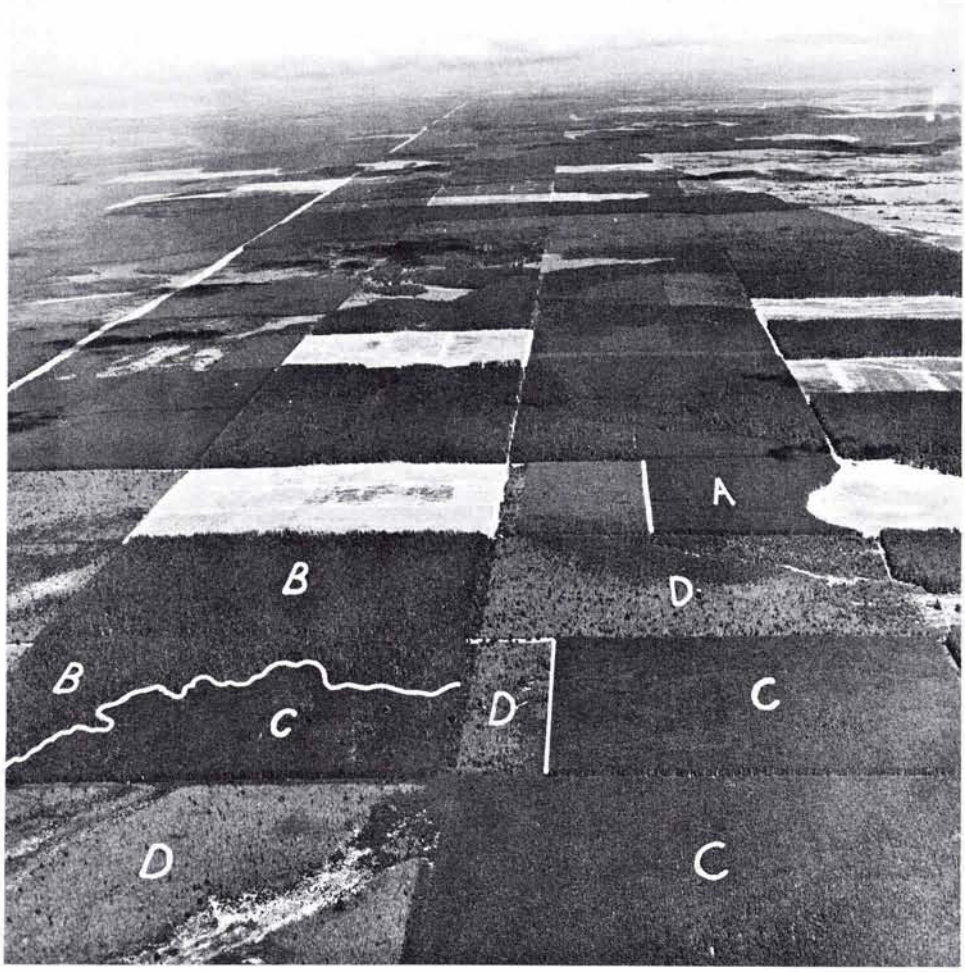

FIG. 1. A portion of Kaingaroa State Forest near Rotorua, New Zealand. Plantations marked are *Pinus nigra (A), Pinus radiata (B), Pinus contorta (C),* and *Pinus ponderosa (D)* (Courtesy of New Zealand Forest Service).

In this instance, a special trial was made to compare parallax measurements on sequential photographs obtained with both 30-degree and 60-degree camera lenses. The six photo interpreters decided that exposures taken with the 30-degree lens and a *stretched* air base (minimum forward overlap) were preferable to those made with a 60-degree camera angle; hence the photographs for the present study were taken with a Zeiss RMK-A-60/23 aerial camera having a 30-degree lens angle and a focal length of 614.98 mm (24 inches).

Photographic coverage of the study area at a scale of 1:3,000 was obtained by new Zealand Aerial Mapping, Ltd. on 18-October 1970. This large scale was specified to offset limitations arising from the use of simple interpretation equipment and relatively unskilled personnel. Exposures on both panchromatic and color films (Kodak Type 2445) were made at 10:30 to 10:40 a.m., N.Z. Standard Time, resulting in a sun elevation angle of 54 degrees. Forward overlap for the exposures was maintained at 50 to 54 per cent to provide maximum parallax with the narrow-lens camera.

INTERPRETATION

During the training period for the six photo interpreters, it was found that superior measurements could be made on positive film transparencies instead of relying on conventional paper prints. Therefore, each interpreter made the following measurements, first on the panchromatic film transparencies, and

(about 2 months later) on the color film transparencies:

- Tree counts for each of the twenty 0.1-acre plots (total: 304 trees).
- Average parallax difference for each individual tree on each plot.
- Average crown diameter for each tree.

Results

Tree counts. Three of the six interpreters were within ± 2 trees of the correct total (304) on the panchromatic photographs, whereas four interpreters achieved this level of accuracy on the color photographs. More importantly, the number of *correct counts* on individual plots improved considerably with the use of the color photographs. As a rule, individual plot counts that are within ± 1 tree of the correct value were regarded as acceptable for this type of inventory system.

Tree heights and crown diameters. For such photographic measurements to be acceptable, it had been decided that heights should be within ± 5 feet of the correct (ground) values and crown diameters within ± 2 feet.

For the panchromatic photographs, four of the six interpreters were within acceptable limits for tree heights on at least 90 percent of the trees; however, only one interpreter had 90 percent of his crown diameter measurements within ± 2 feet.

By contrast, the color photographs provided considerably better results for both measures: all six interpreters had at least 90 percent of their height measurements within ± 5 feet, and four men had at least 90 percent of their crown diameter evaluations within ± 2 feet.

Discussion of Results

The combination of resolution, contrast, and color rendition of Kodak Type 2445 Aerocolor film was greatly superior to that exhibited by the panchromatic emulsion. Thus the pointed tips (leaders) of radiata pines that were impossible to distinguish on the panchromatic film were easily seen and measured on the color transparencies. In like fashion, the obvious contrast between the tree crowns and lesser vegetation permitted easy ground parallax readings on the color film, although such readings were quite troublesome on the black-and-white transparencies.

Contrary to previous beliefs, the Zeiss RMK-A-60/23 aerial camera with a 30-degree camera lens angle and a 24-inch focal length *is suitable* for parallax measurements, provided overlap of successive exposures can be maintained at around 50 to 54 percent. This *minimum overlap* assures a reasonable degree of vertical exaggeration in the stereoscopic model.

Acknowledgments

This cooperative study was made by the Forest Research Institute, Rotorua Conservancy, and staff personnel from Kaingaroa State Forest, New Zealand Forest Service. At the time of the study, T. E. Avery was a Senior Research Fellow, sponsored in Rotorua by the New Zealand National Research Advisory Council.